Medicina Sportiva (2014), vol. X, no 4, 2447-2451
Journal of Romanian Sports Medicine Society

The study of predictor's anthropometric parameters of upper limb with elbow carrying angle in athletes

Daneshmandi Hassan[1], Shahrokhi Hossein[2], Pegah Rahmani[3], Nazary Sharif Hossein[4]
[1]*Faculty of Physical Education and Sport Sciences, Iran*
[2]*Kharazmi University, Faculty of Physical Education and Sport Sciences, Iran*
[3]*University of Isfahan, Faculty of Physical Education and Sport Sciences, Iran*
[4] *Guilan University, Faculty of Physical Education, Iran*

Abstract. The angle between the arm and the forearm in the frontal plane called the carrying angle, which has an important role when carrying loads. There is no more information about carrying angle of athletics in relation to performance, injuries, abnormalities and anthropometric parameters of them in literature. The aim of this study is the comparison of carrying angle in athletic and non-athletic and relationship of predictor's anthropometric parameters of upper limb with elbow carrying angle in athletes. 20 healthy male available athletes (age 22.25±1.88yr, height 182.78±5.49cm, weight 75.35±3.19kg and athletic experience 9.38±3.77yr) and 20 healthy male non-athletes (age 22.80±2.01yr, height 179.35±6.25cm, weight 71.10±2.30kg) participated in this study. Anthropometric variables including shoulder-elbow length, elbow-wrist length. Arm span was measured by meter and carrying angle measured by universal goniometer. Data were analyzed by using of independent t test, correlation test and regression. The results showed a significant difference between carrying angle in athletes and non-athletes ($p \leq 0.05$). There was also a significant relation between elbow-wrist length and carrying angle ($p \leq 0.05$), but no significant relation between shoulder-elbow length, arm span and carrying angle. The results of regression showed that among the variables shoulder-elbow length, elbow-wrist length and arm span, shoulder- elbow length was the best predictors of carrying angle. According to results of this study athletes who have greater forearm are more exposure carrying angle changes and require special medical care in upper extremities to maintain normal elbow alignment.
Key words: c*arrying angle, anthropometry, athlete, elbow joint*.

Introduction

Posture is the relative alignment of the various body segments with one another (1). When a person has good posture, the body's alignment is balanced so that stress applied to the body segments is minimal. When a person has poor posture, the body's alignment is out of balance, causing exaggerated stresses to various body segments. Over time this continual stress, even at relatively low levels, causes anatomical adaptation. These changes alter the individual's ability to perform and affect the body's overall efficiency (1). The elbow joint is a complex structure that performs an important function as the mechanical link in the upper extremity between the hand, wrist, and shoulder. Our particular interest was focused on the angle between the arm and the forearm in the frontal plane called the carrying angle, which has an important role when carrying loads (2-4).

When the forearm is completely extended and supinated, as in carrying an object, it is not in line with the arm but is deflected laterally. This lateral deflection is referred to as the carrying, or cubital, angle (2, 5, 6). This angle is most apparent and best seen when the shoulder is externally rotated, the elbow is completely extended, and the forearm is supinated (2).

There are minor differences in carrying angle in several reports that could be due to morphological differences in the populations of the study, age and sex of the participants, especially the tools and methods of measurement. However, Paraskevas et al (2004) reported the carrying angle is between 0 to 25 degrees (6). Purkait et al (2004) reported carrying angle was about 7 degrees in men and 13 degrees in women (5). Chang et al (2008) stated that carrying was of 13 degrees in men and 10 in women (3).

Williams et al (2006) reported a 10-degree angle at full extension (7).

A recent study of healthy children (600 elbows) showed range of motion of the elbow and carrying angle increase with age to skeletal maturity (3). The carrying angle is reported to increase with age and to be greater in girls than boys but conflicting data exist even on these facts and on its association with height, humeral length, ulnar length and hyperlaxity (8). When an object with a certain width needs to be carried in one hand (e.g. a bucket), people will often spontaneously bring the upper arm in a slight lateral rotation and the forearm in supination, thus making functional use of this carrying angle in order to avoid contact between the carried load and the lower limb at the same side. In this condition, the valgus angle of the elbow is helpful in leading the hand towards a position above the centre of mass of the weight to carry (9).

That whether the increase or decrease of this angle, known as Cubitus Valgus or Cubitus Varus in what extent, has effect on sport performances and incidence of injuries and other disorders is not clear and needs to be studied more. There is a notion that certain activities or sports may predispose athletes to developing posture deviations; however, valid, objective data are lacking (10).

Studies have been mainly in the lower limbs and spine in a weight bearing and in a closed kinematic chain can exacerbate distortions and are less about other organs. For example Tamakaya et al (2009) reported that for every 5-cm as increase, the risk of prevalent vertebral deformities increased by 1.5-fold, after adjusting for those variables (11). Therefore, the main question of this research was: is there an association between carrying angle and its anthropometrics characteristics?

Material and Method

20 healthy athletes include volleyball, handball, and basketball with overload movements pattern took part in this research. 20 healthy non-athletes also were participated. Anthropometric dimensions include arm spam, arm length, forearm length and carrying angle were measured in two limbs of subjects in standard methods as below.

Arm Span. Arm Span is the distance between the tip of the middle (longest) finger of each hand (excluding the fingernails) when both arms are extended laterally and maximally to the level of the shoulders. The subject stand with the feet together and so that his or her back is against the wall. The arms are outstretched laterally and maximally at the level of the shoulders in contact with the wall, and with the palms facing forwards. The tip of the middle (longest) finger (excluding the fingernail) of the right hand is kept in contract with the block, while the zero end of the tape is set at the tape of the middle (longest) finger (excluding the fingernail) of the left hand (11-13).

Arm length. This measurement is made using an anthropometer configured as a sliding-beam caliper. The subject wears clothes that allow the body position to be seen. The shoulders and arms are bare. The subject stands erect on a flat surface with his or her weight distributed evenly on both feet, the head positioned in the Frankfort Plane and the line of sight horizontal.

The shoulders and upper arms are relaxed, with the shoulders drawn back and the upper arms hanging loosely at the subject's sides. Weight is distributed equally between the feet. Both elbow are flexed to place the ulnar surfaces of the forearms and the hands in the horizontal plane and parallel to each other.

The beam of the anthropometer is positioned parallel to the posterior aspect of the arm. While maintaining the flexed bladed of the anthropometer in firm contact with the superolateral aspect of the acromion, the measurer moves the sliding blade of the anthropometer into firm contact with the posterior surface of the olecranon process of the ulna. The measurement, which is the distance between the landmarks projected parallel to the longitudinal axis of the upper arm, is recorded to the nearest 0.1cm (13).

Forearm length. Elbow-wrist length has been measured with the elbow flexed at 90 degrees and the posterior surface of the arm in contract with a plane vertical surface. The flexed arm of the caliper is positioned to make firm contact with the most posterior point overlying the olecranon, while the sliding arm of the caliper is aligned with the most distal palpable point of the styloid process of the radius. During this measurement, the arms of the sliding caliper are held perpendicular to the long axis of the forearm. This measurement is recorded to the nearest 0.1cm (13).

Carrying angle. Measurements were made by placing the arm of the subject on the right of the device, with the forearm maintained fixed, fully extended, and supinated (2). A universal long goniometer was placed with its hinge in the centre of the cubital crease (midway between the medial and lateral humeral condyles). The tips of the two axes of its arms were directed one toward the lateral edge of the acromion (easily palpable in children) and the other toward the midpoint of the radial and ulnar styloid (2, 4, 8).

Data Analysis. The pilot study with 15 athletes was done. The internal reliability coefficient and standard error EMS (ICC and EMS) were reported in table I. Independent t-test was used for comparing the carrying angle between two groups of subjects. Also, Pearson test was used between anthropometric characteristics and carrying angle. Stepwise regression method was applied for predicting of variables. All tests were set at a significance level of P≤0.05 by SPSS software version 16.

Results

The results (see Table II-IV) indicated that the carrying angle in athletes is more than in non-athletes and based on the results of the independent t test, the difference between athletes and non-athletes carrying angle was significant (90/2 = t, 006/0 = p). The results also showed that there is no significant relationship between the carrying angle and arm length (007/0 = p), but there exists a significant relationship between carrying angle, arm span variables and arm's length.

Stepwise Method, the results of regression showed that only forearm length variable is the best predictor of carrying angle (344/0 = R2, 586/0 = β) among other variables include arm spam, forearm and arm length. (carrying angle= (921/0) (length of forearm) - 382/23).

Variable	*Athlete*	*Non-athlete*
Arm Span	182.45 ± 5/88	178.30 ± 6.68
Arm length (cm)	37.17 ± 1.54	36.25 ± 1.93
Forearm length (cm)	27.07 ± 0.94	26.50 ± 1.27
Carrying angle (˚)	10.85 ± 2.43	8.80 ± 2.01

Table I. The internal reliability coefficience and standard error EMS

Variable	ICC	SEM
Arm Span	0.97	0.63
Arm's length	0.99	0.75
Length of forearm	0.99	0.94
Carrying angle	0.96	1.03

Table II. Quantitative Description of variables

Variable	*Correlation coefficient*	*No of cases*	*P value*
Arm Span	0.359	20	0.12
Forearm length	-0.586	20	*0.007
Arm length	0.265	20	0.277

Table III. Correlations between anthropometric variables of carrying angle

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.586[a]	0.344	0.307	2.02555

Table IV. Predictors (Constant) elbow-wrist - Model Summary

Discussion

The results of this study indicated that there were significant differences between the carrying angle of the athletes of volleyball, basketball, handball and non-athletes. In a detailed biomechanical and kinesiological analysis named Hubschbr Muscular Theory it is show that the external deviation of the forearm is due to the action of two powerful muscles such as brachioradialis and extensor carpi radialis longus. These muscles, because of their topography (they arelocated at the radial side of the forearm), abduct the forearm radially and thus contribute to the formation of the carrying angle and in laborers the action of these muscles is balanced by the opposite acting ulnar-sited flexor muscles of the forearm. In this way, the carrying angle is less obvious (14). This ''muscular theory'' was supported by Hubscher (6). According to him, when the forearm is in extension, the head of the radius and the coronoid process of the ulna press in the same way the inferior end of the humerus. During flexion of the forearm, however, the action of the brachioradialis and extensor carpi radialis longus is stronger than the action of the ulnar-located flexor muscles, due to the higher origin of these muscles from the shaft of the humerus. The result is that the forearm deviates radially and thus forms the carrying angle (6).

The ''muscular theory'' of the carrying angle formation is supported by the fact that (a) this angle is more obvious in individuals of athletic and obese constitution, where the muscular system is well developed, (b) the angle is more obvious right in right-handed individuals and left in lefthanded individuals, and (c) the angle is more obvious (6).

The findings of this study can be justified with regard to the population of athletes who play in sports mostly requiring side organs activities (volleyball, handball and basketball) and based on Hubscher theory of muscle. Repetitive and combined movements of flexor, extensor and pronation and supination in receiving and throwing and hitting and also received a mechanical force, which enters into joint in form of valgus, as it happens in fallings, volleyball dive and handball falling, can explain the kinematical and pathomechanical relationship. A closer answer to adaptation mechanisms in question requires further investigation and this study is the first research in this field.

This study showed that there is a significant relationship between the carrying angle and forearm length and based on regression analysis, of the factors arm span, forearm and arm length, only the length of the forearm variable is the best predictor of carrying angle and the results of this study is consistent with the results of whispers et al (1999) (15).

When the forearm is placed in pronation position the proximal ulnar be angled. Compare to the outer part, inner part has more movement on the articular surface. So less pressure is placed on the inside edge of the pulley and the outer edges will grow more. If someone is short resulting in shorter ulnar bone lengths, due to the shorter lever arm in the pronation, proximal forearm angle is greater. So in a person with short height, compare to a person with longer forearm length, because of a greater movement on the inner surface of the inner ulnar and further growth, more carrying angle will be formed. Carrying angle is formed in response to pronation action and depends on the forearm bone length (lever length). Longer arm length reduces the angulation of the proximal forearm during pronation and therefore reduces the angle shipped (6, 15).

The height is inversely related to carrying angle. Studies have shown that the average height of females is lesser (156.8 cm) than the average height of males (169.9), so the average carrying angle is greater in females than in males (15). Therefore it seems more research with more subjects in longitudinal study models need to prove this relation in future. At the present, it is impossible to claim for any strong relationship and also applying any intervention in human samples. And thus, it is just emphasized on the value of the variables of predictive of anthropometric aspects over carrying angle variables that seems to be of particular importance in the study of sports medicine. However, the relationship between physical activity and movement patterns of continuous and repeated to specific injuries previously been studied by many researchers. But such studies on anthropometric characteristics of athletes as a raw talent to develop abnormalities have been observed rarely. Measuring of carrying angle and its role in the athletic skills and secondary postural abnormalities will be studied in future issues that it seems so far has been less investigated and this research has been focused on the need to study it. However, findings of this research on the relationship between anthropometric dimensions of athletes with the angle in question arise the necessity to design and implement a systematic screening and assessment bodies to emphasize on recognition of the potential and talented athletes to develop some abnormalities of secondary postural condition. Clearly identify athletes who are bigger in the length of the forearm and based on the findings of the present study are more subject to Carrying angle changes, need to be taken care under special sport care and possibly need special training programs for side organs in order to reduce injury risks and adverse changes in its structure and their elbow.

Further investigation of matched age, gender, fitness level, and movement patterns in terms of long-term prospective research protocol can be beneficial because there is not much we know about carrying angle and its relationship with physical activities and susceptibility to injury or other secondary abnormalities in athletes.

References

1. Houglum PA (2010). *Therapeutic exercise for musculoskeletal injuries*, Human Kinetics Publishers.
2. Zampagni ML, Casino D, Martelli S, Visani A, Marcacci M (2008). A protocol for clinical evaluation of the carrying angle of the elbow by anatomic landmarks. *Journal of Shoulder and Elbow Surgery*; 17(1): 106-12.
3. Chang C-W, Wang Y-C, Chu C-H (2008). Increased carrying angle is a risk factor for nontraumatic ulnar neuropathy at the elbow. *Clinical orthopaedics and related research*; 466(9): 2190-5.
4. Golden DW, Jhee JT, Gilpin SP, Sawyer JR (2007). Elbow range of motion and clinical carrying angle in a healthy pediatric population. *Journal of Pediatric Orthopaedics; B* 16(2): 144-9.
5. Purkait R, Chandra H (2004). An anthropometric investigation into the probable cause of formation of 'carrying angle': a sex indicator. *Journal of Indian Academy of Forensic Medicine*; 26(1): 14-9.
6. Paraskevas G, Papadopoulos A, Papaziogas B, Spanidou S, Argiriadou H, Gigis J (2004). Study of the carrying angle of the human elbow joint in full extension: a morphometric analysis. *Surgical and Radiologic Anatomy*; 26(1): 19-23.
7. Hennrikus WL (2006). Elbow disorders in the young athlete. *Operative Techniques in Sports Medicine* ; 14(3): 165-72.
8. Balasubramanian P, Madhuri V, Muliyil J (2006). Carrying angle in children: a normative study. *Journal of Pediatric Orthopaedics*; *B* 15(1): 37-40.
9. Van Roy P, Baeyens J, Fauvart D, Lanssiers R, Clarijs J (2005). Arthro-kinematics of the elbow: study of the carrying angle. *Ergonomics*; 48(11-14): 1645-56.
10. Hrysomallis C, Goodman C (2001). A review of resistance exercise and posture realignment. *The Journal of Strength & Conditioning Research*; 15(3): 385-90.
11. Tamaki J, Iki M, Kadowaki E, Sato Y, Kagamimori S, Kagawa Y, et al. (2009). Arm span increases predictive value of models for prevalent vertebral deformities: The Japanese Population-based Osteoporosis (JPOS) Study. *Maturitas;* 64(4): 241-5.
12. Chhabra S (2008). Using arm span to derive height: impact of three estimates of height on interpretation of spirometry. *Annals of thoracic medicine;* 3(3): 94-9.
13. Lohman TG, Roche AF, Martorell R (1988). *Anthropometric standardization reference manual*. Champaign, IL: Human Kinetics Press
14. Fick R (2013). *Handbuch der Anatomie und Mechanik der Gelenke unter Berücksichtigung der bewegenden Muskeln*, BoD–Books on Demand.
15. Khare G, Goel S, Saraf S, Singh G, Mohanty C (1999). New observations on carrying angle. *Indian Journal of Medical Sciences*; 53(2): 61.

Corresponding author
Nazary Sharif Hossein
Guilan University, Faculty of Physical Education, Iran
E-mail: h.nazary67@yahoo.com

Received: November 13, 2014
Accepted: December 05, 2014